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GPCP-AIP/2 - ATLAS: UK NWP MODEL - RELATIVE HUMIDITY PROFILE

by

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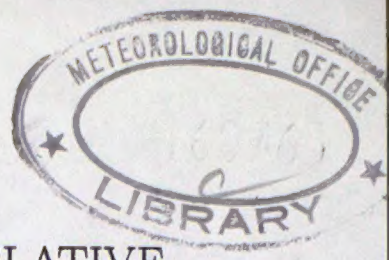

GPCP-AIP/2 - ATLAS: UK NWP MODEL - RELATIVE HUMIDITY PROFILE.

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Introduction

As part of the Global Precipitation Climatology Project - Algorithm Intercomparison Project - 2 (GPCP-AIP/2) (WMO 1989) data from the UK Met. Office's numerical weather prediction (NWP) model [1] (Cullen 1991) have been supplied to participants in AIP/2 to support their work on rainfall algorithms. The NWP model produced many fields; only a portion of them was distributed to the participants, this being reported in *Tab.1.* Data were provided twice a day (00:00 and 12:00 UTC) for the period 1st February to 9th April 1991.
Because of the expected correlation between the water vapour vertical distribution and the location of precipitating areas within a cloud system, statistical analyses were carried out on the relative humidity fields in order to:
- test the quality of the data;
- study the statistical properties of the data;
- help select interesting cases from the point of view of estimating precipitation;
- compare with similar analyses of data sets from other instruments during the GPCP-AIP/2 Campaign.
This report shows the results of such an analysis.
The data origin and characteristics are described in Section 1.
Section 2 describes the analyses applied to the data set.
In Section 3, some comments on the data set are reported.

1 Data Origin and Characteristics

The data supplied were produced by the Met. Office's limited area model that was operational at the time of the AIP/2 campaign: the model used has since been superseded. All the fields supplied to the GPCP-AIP/2 participants were taken from the analysis stage of the modelling cycle, ie prior to the forecast run. It is believed that the fields provided are therefore the best consistent dataset representing the structure of the atmosphere available.

The model provided data for a grid that extended from 30.0° N to 79.5° N and from 80.625°W to 40.3125°E. The grid resolution of the model was 0.75° [N-S]; 0.9375° [E-W] for a total 67 rows and 130 columns (8710 grid points total).

In this analysis, the data were selected for a subarea covering approximately the GPCP-AIP/2; the actual area is shown in *Fig.1.* The data used were included in the box limited by 55.5°N - 42.0°N and 18.75°W - 15.9375°E, resulting in an array of 19 lines and 38 columns (total points: 722).

The original precision of the relative humidity values was 1±%.

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[1] That is the version that was operational in early 1991

2 Results Summary

In *Tab.2* is summarised the amount of data used for the analyses.
For each level and each file, the following products have been produced:

- Number of grid points analysed [N];

- Minimum [min] and maximum [MAX] value;

- Mean:

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$$

- Standard Deviation:

$$s_2 = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{N-1}}$$

- Coefficient of Skewness:

$$s_3 = \frac{\sum_{i=1}^{N} (x_i - \bar{x})^3}{(N-1) \cdot s_2^3}$$

- Coefficient of Kurtosis:

$$s_4 = \frac{\sum_{i=1}^{N} (x_i - \bar{x})^4}{(N-1) \cdot s_2^4} - 3$$

- Frequency distribution for classes as specified in *Tab.3*;

For each month the results are shown in form of summary panels (*Fig.2-19*)

Referring to *Fig.2*, each summary panel contains the following information:
FRAME A: Time series of the number of files available for each day;
FRAME B: Time series of the percentage of grid points of the frame containing useful data;
FRAME C: Time series of the frequency histogram where the contour lines correspond to [1] 1%, [2] 5%, [3] 10%, [4] 15% for the classes reported in *Tab.3*;
FRAME D: Time series of the coefficient of Kurtosis;
FRAME E: Time series of the coefficient of Skewness;
FRAME F: Time series of the Standard Deviation;
FRAME G: Time series of the mean, minimum and maximum values;
FRAME H: Cumulative histogram for the classes reported in *Table 3*;
FRAME I: Frequency distribution [%] of values for the coefficient of Kurtosis;
FRAME J: Frequency distribution [%] of values for the coefficient of Skewness;
FRAME K: Frequency distribution [%] of values for the Standard Deviation;
FRAME L: Frequency distribution [%] of values for mean (continuous line) minimum and maximum (dashed lines).
In the April panels *Fig.4,7,10,13,16,19*, the column of plots on the extreme right represents the same as panels H to L except for the whole period.
The axis limits, interval and unit of measurement are reported in *Table 4*.

For each time series of statistical parameters computed from the images, some basic statistics (minimum and maximum value, mean, Standard Deviation, Skewness and Kurtosis) have been also calculated. The results are shown in (*Table 5.a-f.*) for each month as well as for the whole period (ALL).

3 Discussion of problems

Being the data derived from an operational NWP model, the availability of the data was very high and certainly much better than from any of the the satellite sources (Liberti 1992a, 1992b, 1993). Only few files (three, in February) were missed during the whole campaign. Also the fixed size and location of the analysed data set exclude undesirable effects in the statistics.

It is assumed that a quality control of the data is performed when produced by the model. For such reason the data analysed do not show evident problems.

The results obtained in this analysis have been compared with similar statistics from the COST73 and the METEOSAT data set in Liberti (1992c) in order to establish correlation between each humidity profile level and both the radiometric and the precipitation measurements.

As an example of the application of the results of the statistics, the average relative humidity profiles have been computed for each month (*Fig.20.a-c*) as well as for the campaign (*Fig.20.d*). It is observed that the profile is stable during the campaign. The average profile can be used, for example, in microwave radiative transfer model-based precipitation algorithms as input for the model.
Also *Fig.20.e* shows the average profile of the values of the skewness for the whole campaign. The distribution behaves as expected with negative values for the lower level, where the distribution has a tail in the lower values, increasing to positive values for the higher levels, for which the rare events are the high relative humidity values.

Other fields taken from those listed in *Tab.1* would be expected to contain information correlated with the precipitation (for example the vertical velocity). It is recommended, therefore, that similar analyses should be produced for such fields.

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TABLES

1. PRODUCTS AND LEVELS [mb]:

PRODUCT	[UDM]	950	850	700	500	400	300	250	200	150	100	70	50	30
Geopotential height	m		Y	Y	Y			Y			Y			
Temperature	°C	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
U/V wind component	cm/s	Y	Y	Y	Y		Y		Y		Y			
Vertical velocity	mb/hr		Y	Y	Y			Y			Y			
Relative humidity	%	Y	Y	Y	Y	Y	Y							
Pressure	mb	Mean Sea Level												
Temperature	°C	Surface												
Screen Temperature	°C	1.5 m												

2. DATA STATISTICS:

(A) number of images analysed; (B) % of expected number of images (assuming 2 a day).

Period	A	B
Feb	53	94.6
Mar	62	100.0
Apr	18	100.0
All	133	97.8

3. HISTOGRAM CLASSES [Frame H, Fig. 2-19]:

CLASS	LIMITS [%]	CLASS	LIMITS [%]
1	$0 \leq RH < 5$	11	$50 \leq RH < 55$
2	$5 \leq RH < 10$	12	$55 \leq RH < 60$
3	$10 \leq RH < 15$	13	$60 \leq RH < 65$
4	$15 \leq RH < 20$	14	$65 \leq RH < 70$
5	$20 \leq RH < 25$	15	$70 \leq RH < 75$
6	$25 \leq RH < 30$	16	$75 \leq RH < 80$
7	$30 \leq RH < 35$	17	$80 \leq RH < 85$
8	$35 \leq RH < 40$	18	$85 \leq RH < 90$
9	$40 \leq RH < 45$	19	$90 \leq RH < 95$
10	$45 \leq RH < 50$	20	$95 \leq RH \leq 100$

4. PLOT SCALE AND MARKS:

FR: Reference frame;
Xm: Minimum value for the X-axis;
XM: Maximum value for the X-axis;
DX: Tick mark distance for the X-axis;
UX: Unit for the X-axis;
Ym: Minimum value for the Y-axis;
YM: Maximum value for the Y-axis;
DY: Tick mark distance for the Y-axis;
UY: Unit for the Y-axis;

FR	Xm	XM	DX	UX	Ym	YM	DY	UY
A	1	*	1	DAY	0	2	0.5	FILES
B	1	*	1	DAY	10	101	10	GRIDPOINT % OF THE AREA
C	1	*	1	DAY	0	100	10	RH %
D	1	*	1	DAY	-2	6	1	
E	1	*	1	DAY	-2.5	1	0.5	
F	1	*	1	DAY	0.0	40	5.0	RH %
G	1	*	1	DAY	0	100	10	RH %
H	0	40	5	% of total	0	100	10	RH %
I	0	30	5	% of total	-2	6	1	
J	0	30	5	% of total	-2.5	1	0.5	
K	0	30	5	% of total	0.0	30	5.0	RH %
L	0	30	5	% of total	0	100	10	RH %

*: end of the month

5. STATISTIC OF THE STATISTICS

A	*950 mb*						
	Variable	Statistics of the variable					
		AV	S_2	S_3	S_4	min	MAX
F	AV [%]	74.94	5.00	-0.29	-0.94	64.28	82.91
E	min [%]	12.43	14.32	0.66	-1.15	0.00	42.00
B	MAX [%]	100.00	0.00	0.00	0.00	100.00	100.00
	S_2 [%]	16.41	3.47	0.34	-1.16	11.43	23.81
	S_3	-0.69	0.42	-0.04	-0.79	-1.51	0.18
	S_4	0.74	1.33	0.92	0.06	-1.09	4.27
M	AV [%]	76.05	5.30	-0.58	0.27	59.96	87.01
A	min [%]	27.44	10.75	-0.41	-0.12	0.00	48.00
R	MAX [%]	99.94	0.31	-5.04	25.80	98.00	100.00
	S_2 [%]	14.40	1.95	0.24	-0.94	10.69	18.45
	S_3	-0.52	0.37	-0.27	-0.68	-1.40	0.19
	S_4	0.02	0.67	0.97	0.44	-1.08	1.95
A	AV [%]	71.12	4.44	0.35	-0.82	63.62	80.12
P	min [%]	22.78	14.75	-0.38	-1.29	0.00	44.00
R	MAX [%]	99.94	0.24	-3.77	12.17	99.00	100.00
	S_2 [%]	15.85	3.60	0.60	-0.71	10.94	23.12
	S_3	-0.19	0.34	0.02	-1.22	-0.77	0.38
	S_4	-0.29	0.41	-0.19	-1.04	-0.98	0.41
A	AV [%]	74.94	5.28	-0.29	-0.54	59.96	87.01
L	min [%]	20.83	14.54	-0.18	-1.27	0.00	48.00
L	MAX [%]	99.96	0.23	-6.61	46.51	98.00	100.00
	S_2 [%]	15.40	3.01	0.78	-0.12	10.69	23.81
	S_3	-0.54	0.42	-0.20	-0.57	-1.51	0.38
	S_4	0.26	1.04	1.60	2.69	-1.09	4.27

B	*850 mb*						
	Variable	Statistics of the variable					
		AV	S_2	S_3	S_4	min	MAX
F	AV [%]	67.54	8.30	-0.47	-0.95	49.77	81.21
E	min [%]	5.36	8.86	1.94	3.42	0.00	39.00
B	MAX [%]	100.00	0.00	0.00	0.00	100.00	100.00
	S_2 [%]	22.06	4.29	-0.16	-0.84	13.81	30.89
	S_3	-0.51	0.43	-0.30	-0.47	-1.66	0.32
	S_4	-0.16	0.95	1.06	0.42	-1.27	2.50
M	AV [%]	68.47	8.53	-1.11	0.31	45.78	79.08
A	min [%]	12.85	9.65	0.34	-0.96	0.00	33.00
R	MAX [%]	99.98	0.13	-7.62	56.05	99.00	100.00
	S_2 [%]	19.74	3.66	0.72	0.55	12.70	29.90
	S_3	-0.41	0.36	0.76	0.82	-1.07	0.72
	S_4	-0.39	0.51	0.49	-0.07	-1.37	1.01
A	AV [%]	69.17	5.69	-0.12	-1.18	59.73	77.70
P	min [%]	12.61	13.31	0.46	-1.51	0.00	36.00
R	MAX [%]	100.00	0.00	0.00	0.00	100.00	100.00
	S_2 [%]	20.17	4.99	-0.36	-1.37	11.23	26.42
	S_3	-0.47	0.36	0.06	-0.59	-1.16	0.17
	S_4	-0.25	0.58	0.76	-0.52	-1.03	0.97
A	AV [%]	68.19	8.08	-0.83	-0.14	45.78	81.21
L	min [%]	9.83	10.50	0.83	-0.46	0.00	39.00
L	MAX [%]	99.99	0.09	-11.36	127.02	99.00	100.00
	S_2 [%]	20.72	4.23	0.15	-0.63	11.23	30.89
	S_3	-0.46	0.39	0.09	0.32	-1.66	0.72
	S_4	-0.28	0.73	1.28	2.02	-1.37	2.50

C	*700 mb*						
	Variable	Statistics of the variable					
		AV	S_2	S_3	S_4	min	MAX
F	AV [%]	50.49	9.73	0.18	-0.97	33.64	70.81
E	min [%]	0.15	0.57	3.79	13.56	0.00	3.00
B	MAX [%]	100.00	0.00	0.00	0.00	100.00	100.00
	S_2 [%]	29.51	3.32	-0.75	0.00	20.70	34.69
	S_3	0.09	0.41	-0.29	-0.97	-0.82	0.77
	S_4	-0.98	0.33	0.54	-0.12	-1.53	-0.05
M	AV [%]	53.38	10.41	-0.34	-0.47	28.79	73.00
A	min [%]	1.66	4.36	3.27	10.17	0.00	21.00
R	MAX [%]	99.94	0.40	-6.70	45.22	97.00	100.00
	S_2 [%]	26.18	3.28	0.37	0.15	18.51	34.72
	S_3	0.01	0.41	0.92	0.70	-0.78	1.32
	S_4	-0.78	0.46	2.29	7.00	-1.49	1.25
A	AV [%]	53.45	7.60	-0.03	-1.41	40.48	64.97
P	min [%]	0.11	0.32	2.41	3.73	0.00	1.00
R	MAX [%]	100.00	0.00	0.00	0.00	100.00	100.00
	S_2 [%]	29.00	3.66	-0.11	-0.95	23.25	35.80
	S_3	-0.10	0.34	-0.01	-0.67	-0.76	0.45
	S_4	-0.96	0.40	1.02	0.39	-1.52	0.02
A	AV [%]	52.23	9.84	-0.12	-0.72	28.79	73.00
L	min [%]	0.85	3.09	5.01	26.24	0.00	21.00
L	MAX [%]	99.97	0.27	-10.03	103.41	97.00	100.00
	S_2 [%]	27.89	3.69	-0.09	-0.74	18.51	35.80
	S_3	0.02	0.41	0.37	-0.19	-0.82	1.32
	S_4	-0.89	0.41	1.89	6.60	-1.53	1.25

D	*500 mb*						
	Variable	Statistics of the variable					
		AV	S_2	S_3	S_4	min	MAX
F	AV [%]	44.25	9.23	0.23	-0.53	28.05	65.86
E	min [%]	0.00	0.00	0.00	0.00	0.00	0.00
B	MAX [%]	99.96	0.27	-7.01	47.06	98.00	100.00
	S_2 [%]	29.85	3.07	-0.19	-0.86	23.66	35.61
	S_3	0.34	0.41	-0.31	0.00	-0.71	1.18
	S_4	-0.87	0.50	1.20	1.15	-1.60	0.76
M	AV [%]	45.47	9.94	-0.19	-0.64	23.50	64.89
A	min [%]	0.05	0.28	6.05	36.67	0.00	2.00
R	MAX [%]	99.98	0.13	-7.62	56.05	99.00	100.00
	S_2 [%]	28.49	2.75	-0.14	-0.28	22.52	34.53
	S_3	0.26	0.43	0.51	-0.15	-0.48	1.49
	S_4	-0.82	0.61	2.22	6.06	-1.47	1.97
A	AV [%]	45.30	8.42	-0.12	-0.85	31.89	61.77
P	min [%]	0.11	0.47	3.77	12.17	0.00	2.00
R	MAX [%]	100.00	0.00	0.00	0.00	100.00	100.00
	S_2 [%]	29.38	3.48	-0.51	-0.48	21.59	34.65
	S_3	0.29	0.34	0.15	-0.80	-0.37	0.88
	S_4	-0.95	0.48	0.92	-0.40	-1.49	0.00
A	AV [%]	44.96	9.42	-0.02	-0.59	23.50	65.86
L	min [%]	0.04	0.26	7.03	48.88	0.00	2.00
L	MAX [%]	99.98	0.19	-9.09	84.92	98.00	100.00
	S_2 [%]	29.16	3.03	-0.16	-0.50	21.59	35.61
	S_3	0.30	0.41	0.15	-0.19	-0.71	1.49
	S_4	-0.86	0.55	1.88	4.98	-1.60	1.97

E	*400 mb*						
	Variable	Statistics of the variable					
		AV	S_2	S_3	S_4	min	MAX
F	AV [%]	43.08	7.41	0.16	-0.46	27.78	60.31
E	min [%]	0.00	0.00	0.00	0.00	0.00	0.00
B	MAX [%]	100.00	0.00	0.00	0.00	100.00	100.00
	S_2 [%]	30.01	2.85	-0.33	-0.17	22.25	35.33
	S_3	0.35	0.29	-0.39	0.13	-0.41	0.87
	S_4	-0.92	0.37	1.01	0.61	-1.42	0.14
M	AV [%]	45.36	8.42	-0.08	-0.44	25.10	63.01
A	min [%]	0.00	0.00	0.00	0.00	0.00	0.00
R	MAX [%]	99.85	1.14	-7.62	56.05	91.00	100.00
	S_2 [%]	28.58	2.65	-0.20	-0.72	22.59	33.79
	S_3	0.24	0.35	0.04	-0.82	-0.45	1.02
	S_4	-0.87	0.39	1.01	0.10	-1.41	0.22
A	AV [%]	41.83	7.55	0.35	-0.44	29.33	57.75
P	min [%]	0.00	0.00	0.00	0.00	0.00	0.00
R	MAX [%]	99.89	0.32	-2.41	3.73	99.00	100.00
	S_2 [%]	29.31	2.59	-0.13	-0.24	23.72	34.08
	S_3	0.41	0.34	-0.11	-0.65	-0.21	1.03
	S_4	-0.81	0.48	0.91	-0.14	-1.41	0.30
A	AV [%]	43.97	7.97	0.11	-0.44	25.10	63.01
L	min [%]	0.00	0.00	0.00	0.00	0.00	0.00
L	MAX [%]	99.92	0.79	-10.98	120.89	91.00	100.00
	S_2 [%]	29.25	2.78	-0.18	-0.39	22.25	35.33
	S_3	0.31	0.33	-0.16	-0.50	-0.45	1.03
	S_4	-0.88	0.39	1.03	0.42	-1.42	0.30

F	*300 mb*						
	Variable	Statistics of the variable					
		AV	S_2	S_3	S_4	min	MAX
F	AV [%]	37.41	9.37	1.34	2.80	23.70	73.98
E	min [%]	0.09	0.30	2.75	5.54	0.00	1.00
B	MAX [%]	96.47	2.94	-0.93	0.15	88.00	100.00
	S_2 [%]	26.01	3.27	-0.61	-0.23	17.80	31.01
	S_3	0.51	0.40	-0.74	0.34	-0.73	1.13
	S_4	-0.55	0.64	0.86	-0.55	-1.29	0.98
M	AV [%]	40.10	6.49	-0.35	-0.34	23.47	52.65
A	min [%]	0.05	0.22	4.18	15.42	0.00	1.00
R	MAX [%]	97.98	1.84	-1.16	0.93	92.00	100.00
	S_2 [%]	25.99	2.45	-0.33	0.55	18.41	31.02
	S_3	0.32	0.33	0.67	-0.38	-0.23	1.15
	S_4	-0.73	0.51	2.35	6.40	-1.35	1.34
A	AV [%]	34.36	8.35	-0.41	-0.74	16.32	45.48
P	min [%]	0.00	0.00	0.00	0.00	0.00	0.00
R	MAX [%]	97.94	1.76	-1.26	1.16	93.00	100.00
	S_2 [%]	26.32	3.23	0.00	-1.18	20.48	31.64
	S_3	0.52	0.36	0.65	-0.31	0.10	1.39
	S_4	-0.67	0.59	1.42	1.77	-1.24	1.05
A	AV [%]	38.25	8.19	0.50	1.75	16.32	73.98
L	min [%]	0.06	0.24	3.69	11.58	0.00	1.00
L	MAX [%]	97.38	2.43	-1.35	1.67	88.00	100.00
	S_2 [%]	26.04	2.89	-0.43	0.04	17.80	31.64
	S_3	0.42	0.37	0.04	-0.36	-0.73	1.39
	S_4	-0.65	0.58	1.49	1.78	-1.35	1.34

LIST OF FIGURES

1. The GPCP-AIP/2 area is bounded by the solid line. The dashed line shows the area containing the data analysed.
2. UK MET. OFFICE-NWP RELATIVE HUMIDITY - 950 mb, FEB: SUMMARY
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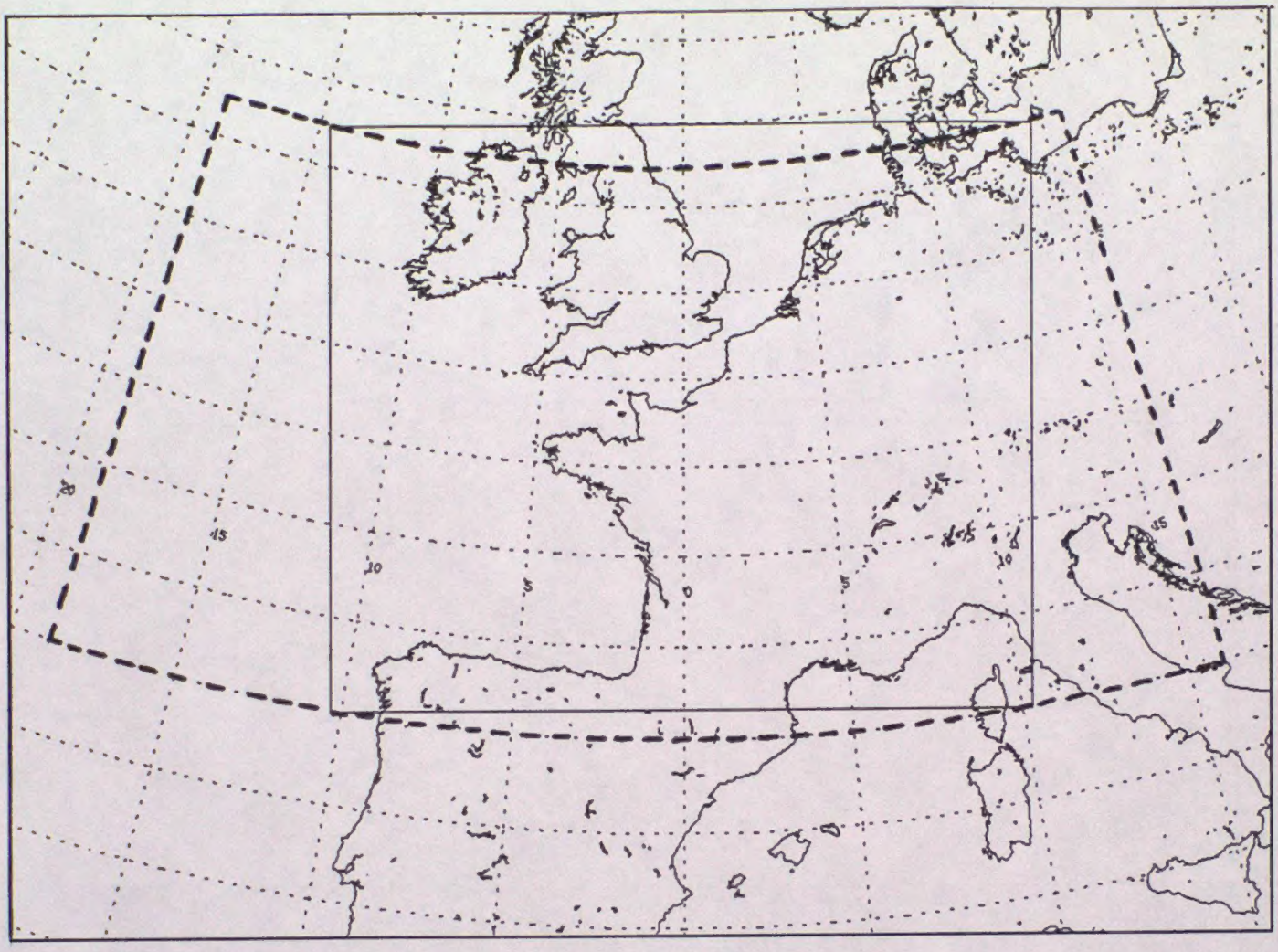
20. Profiles of average relative humidity for each month (**A-C**) and for the whole GPCP-AIP/2 campaign (**D**). In the latter, the single month profiles have also been plotted for comparison with the profile for the whole campaign (continuous line). The error bar on the right of the line represents the average standard deviation; that on the left shows the standard deviation of the average (see *Tab.5*).

    The extreme right panel (**E**) shows the profile of the average values of the skewness for the whole campaign. The error bar represents the standard deviation of the skewness.



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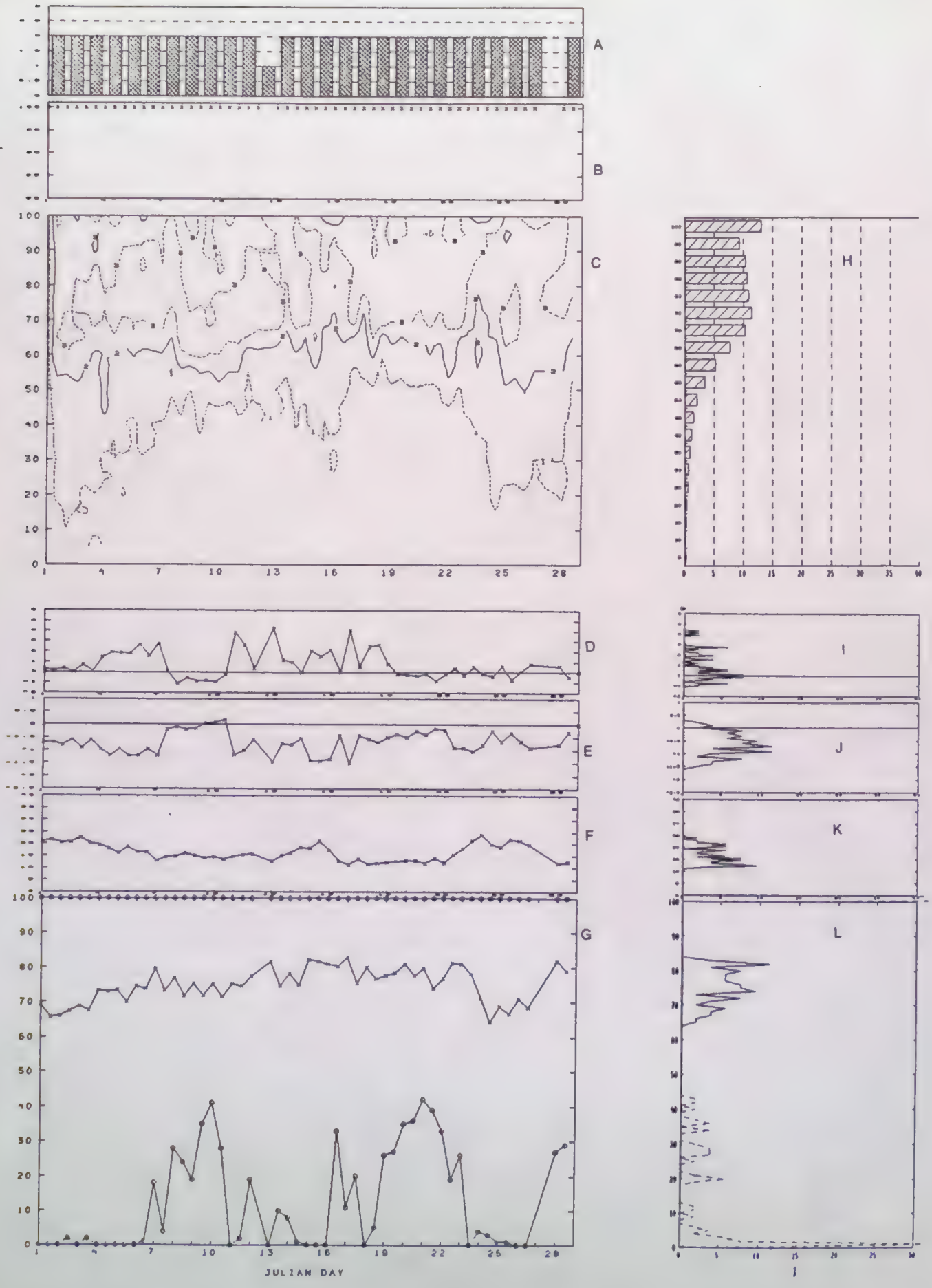

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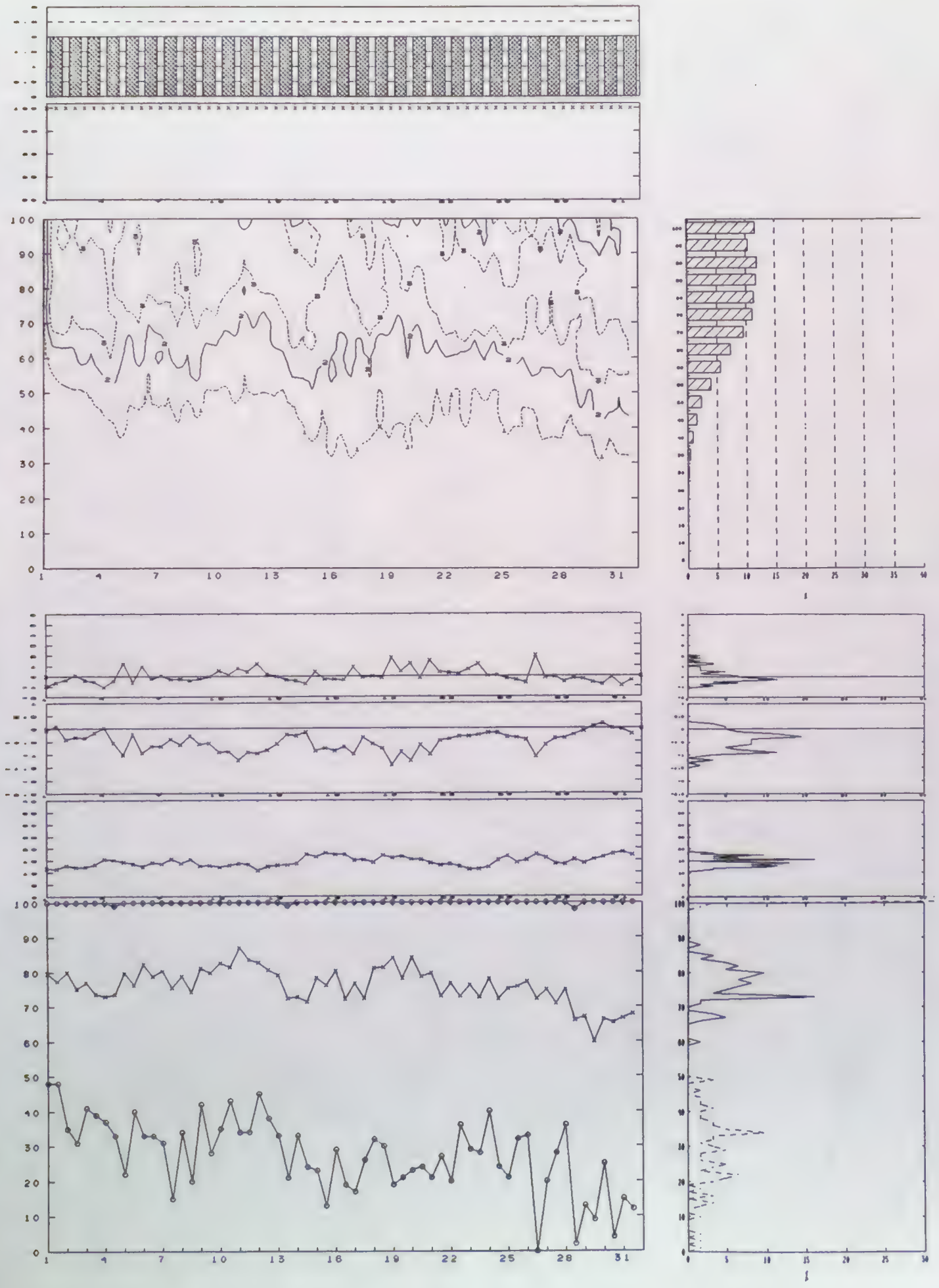

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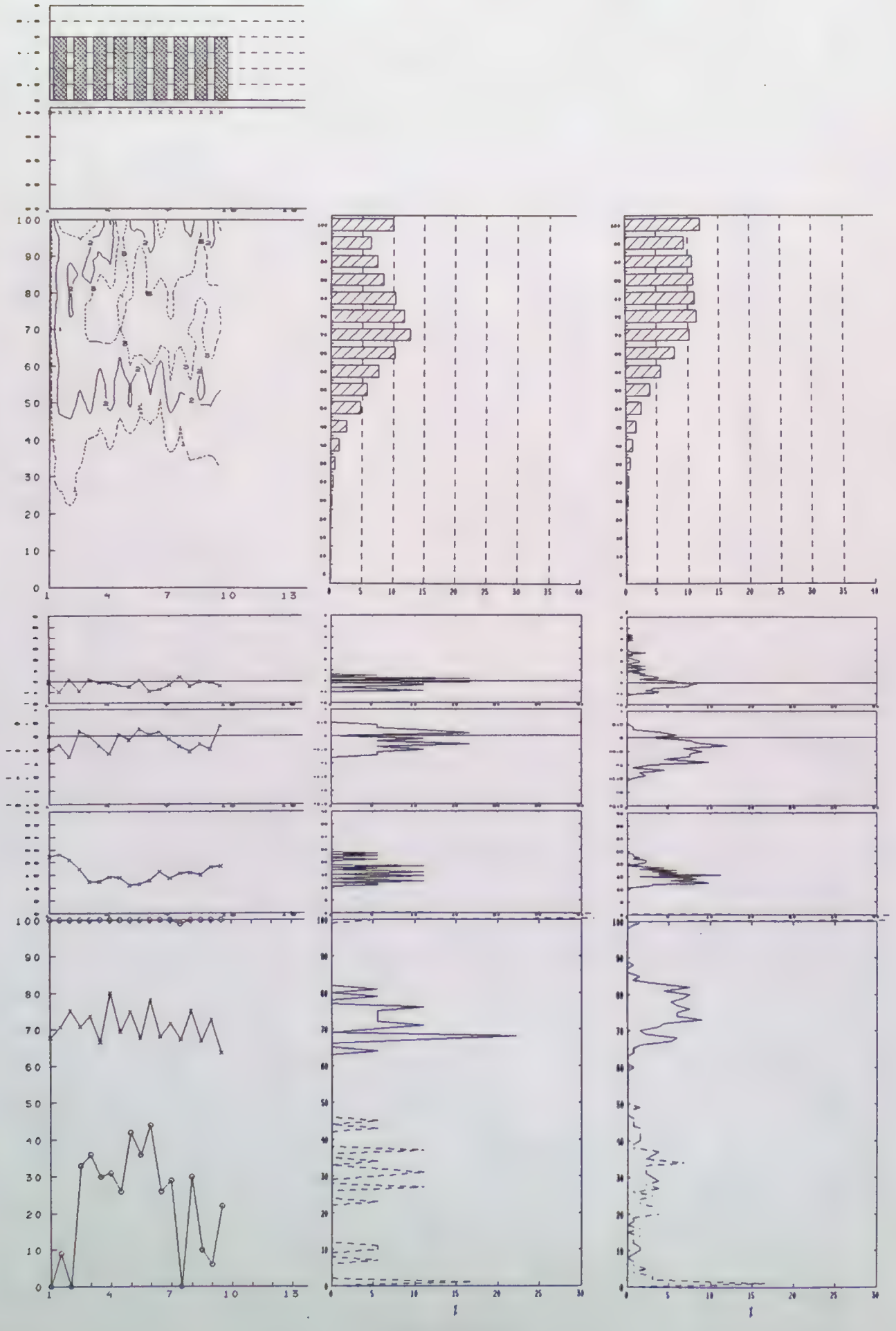

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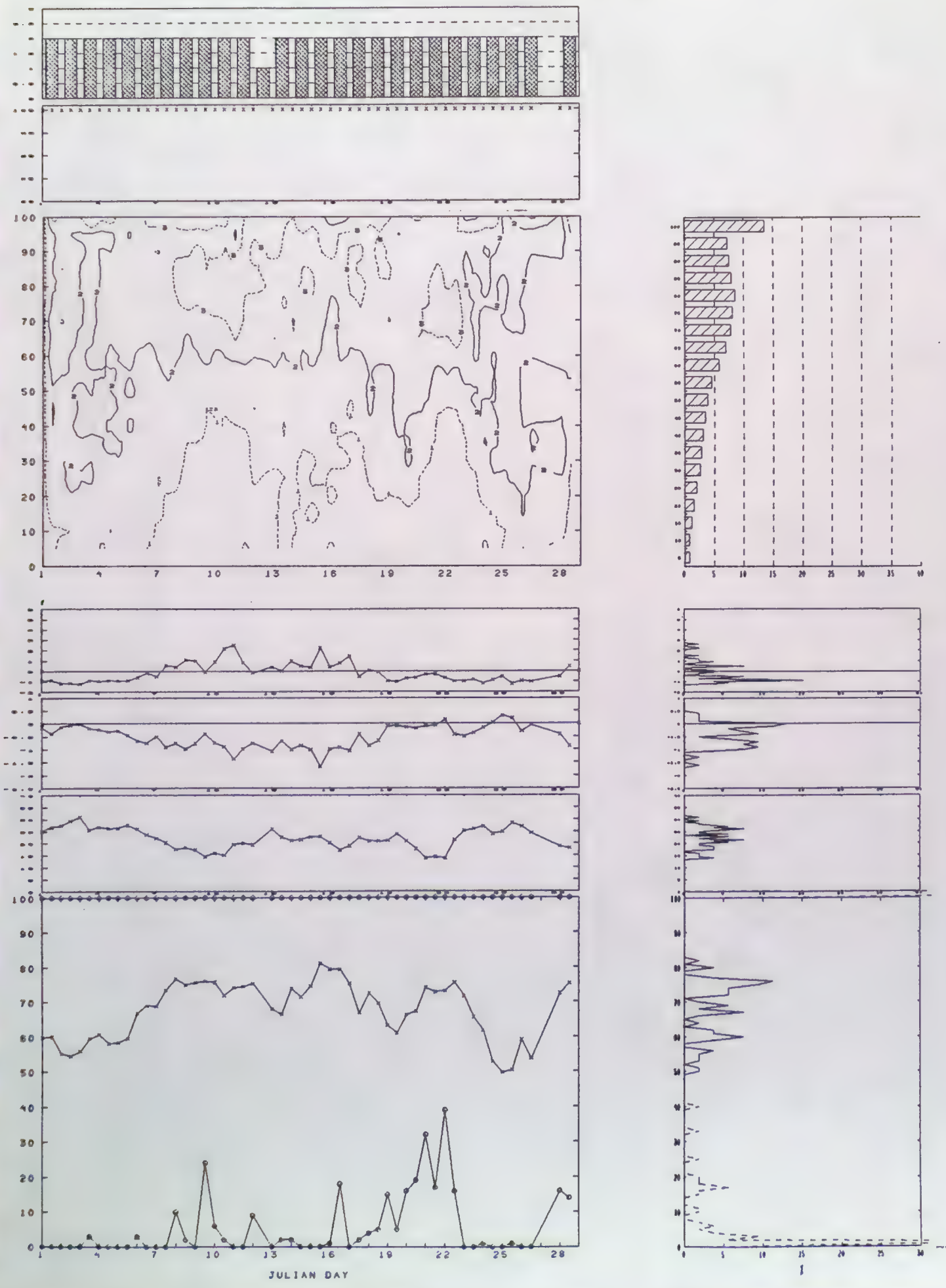

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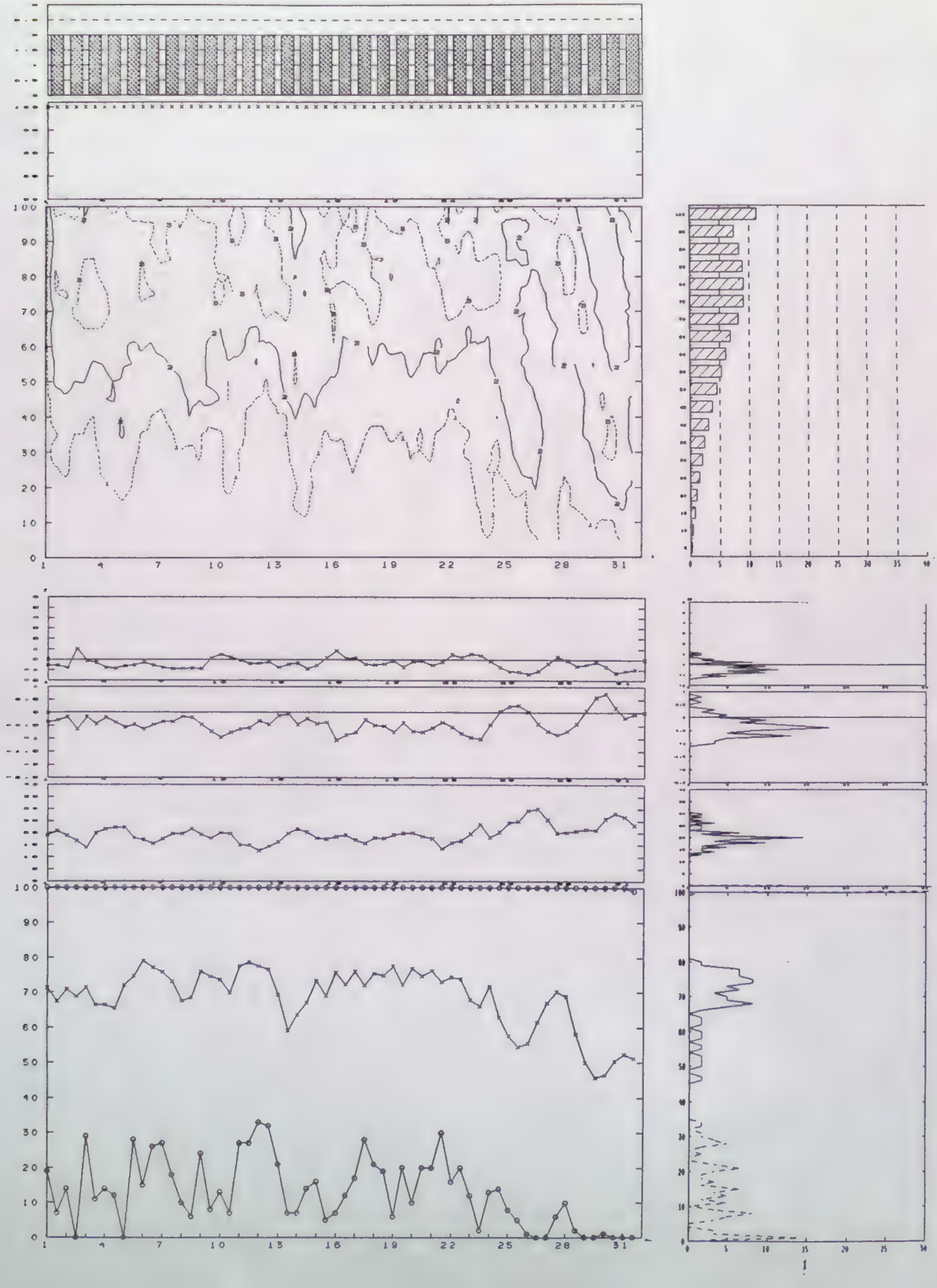

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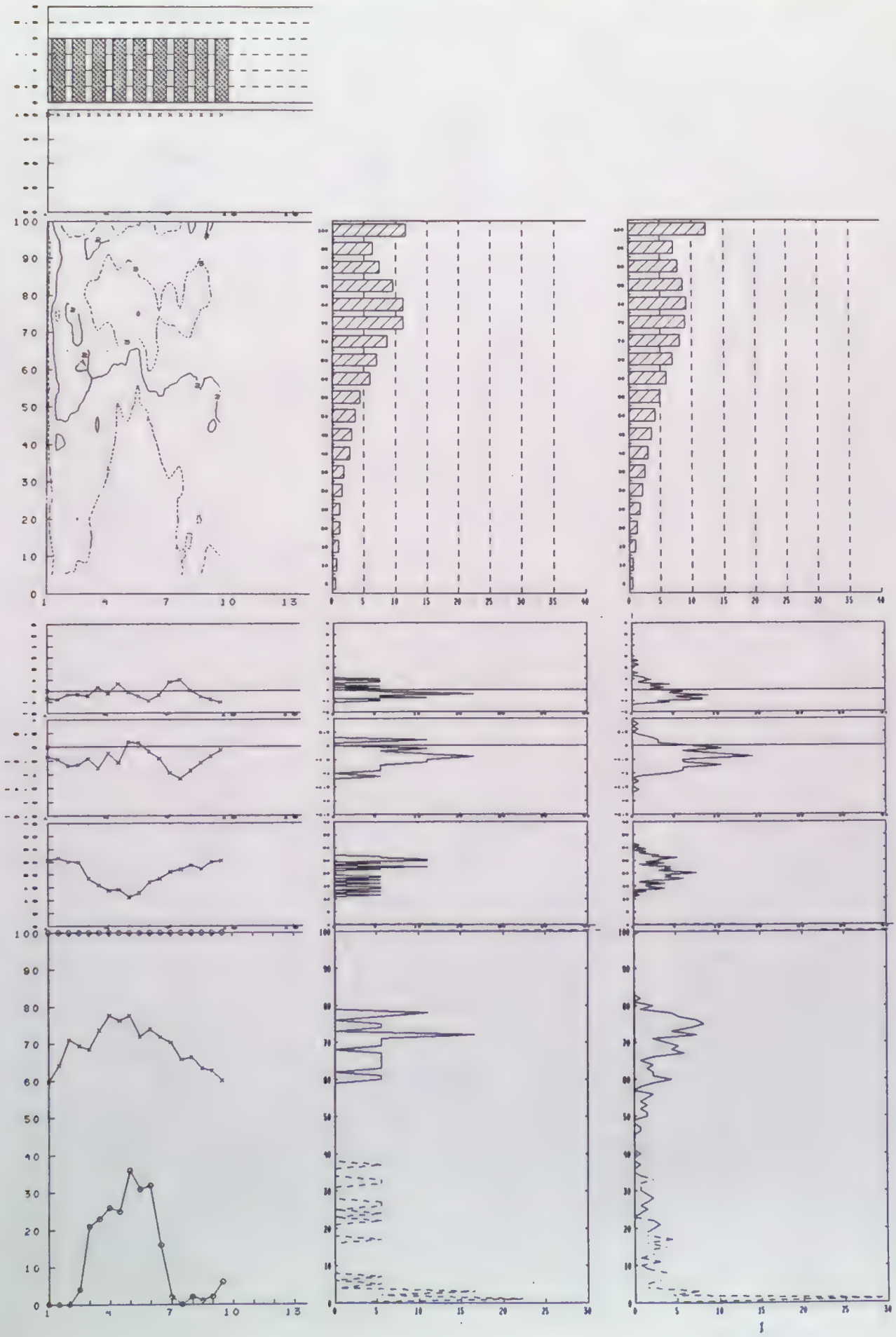

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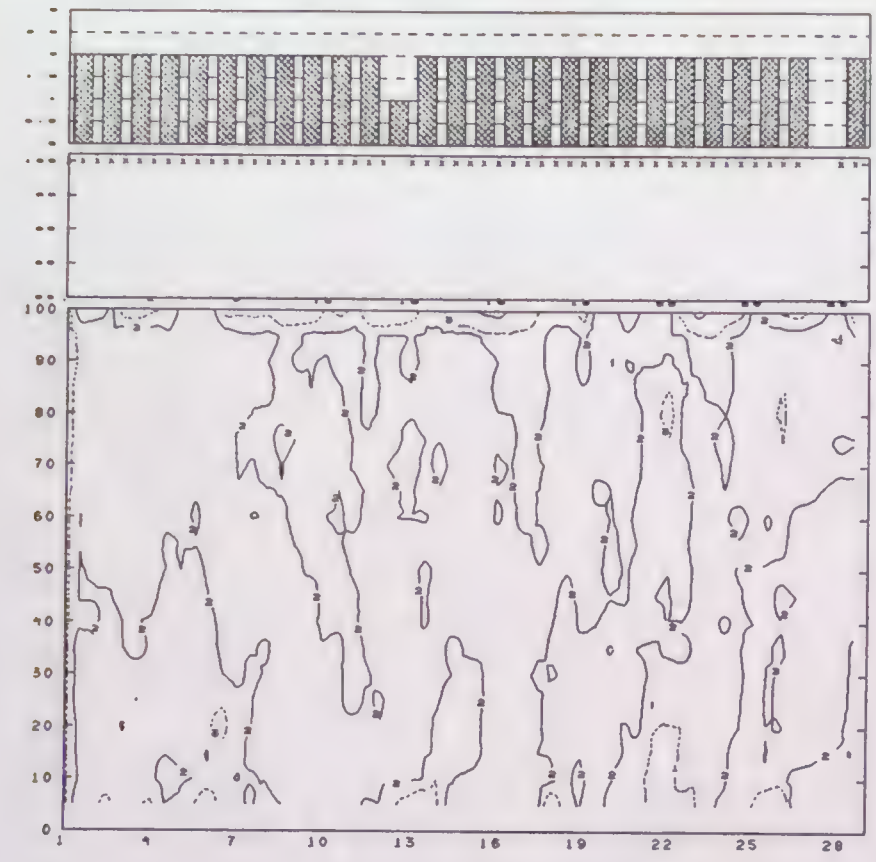

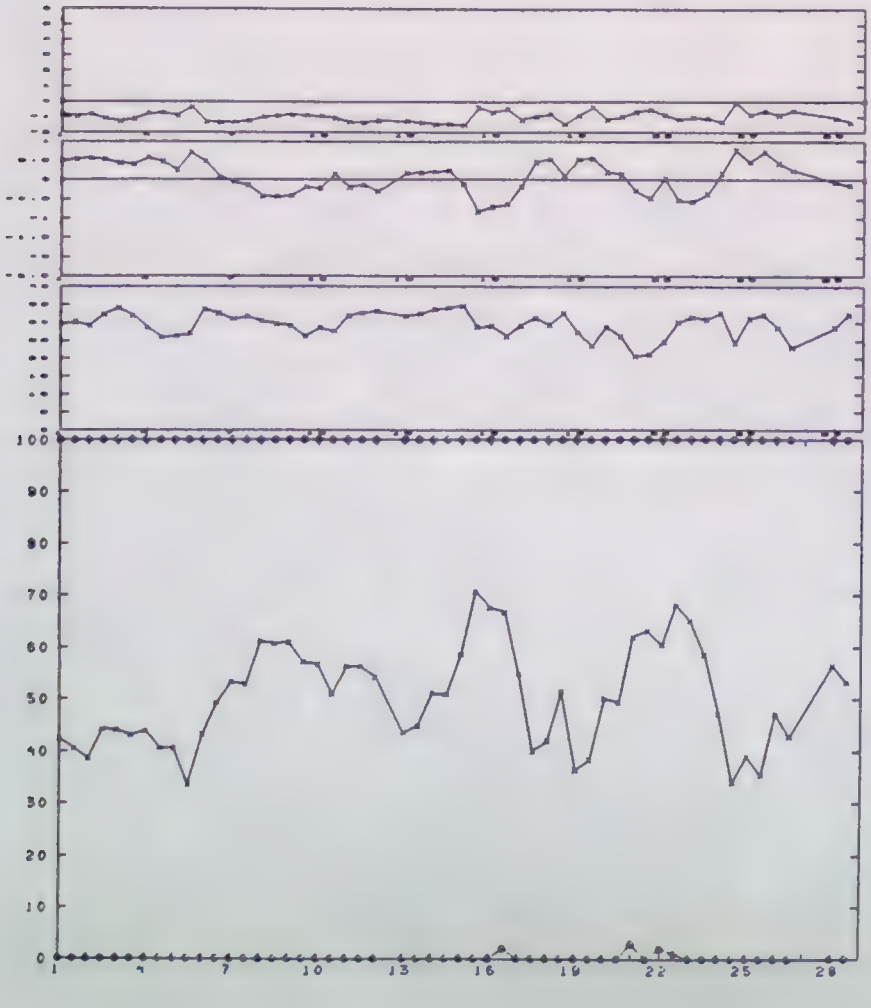

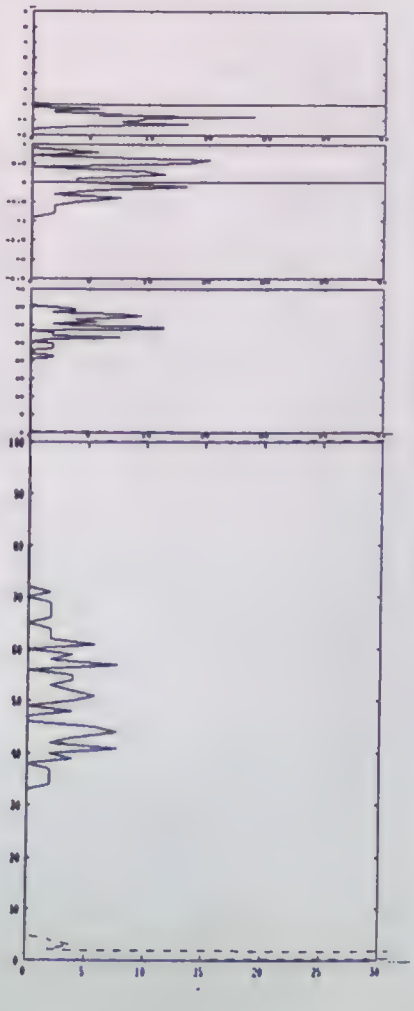

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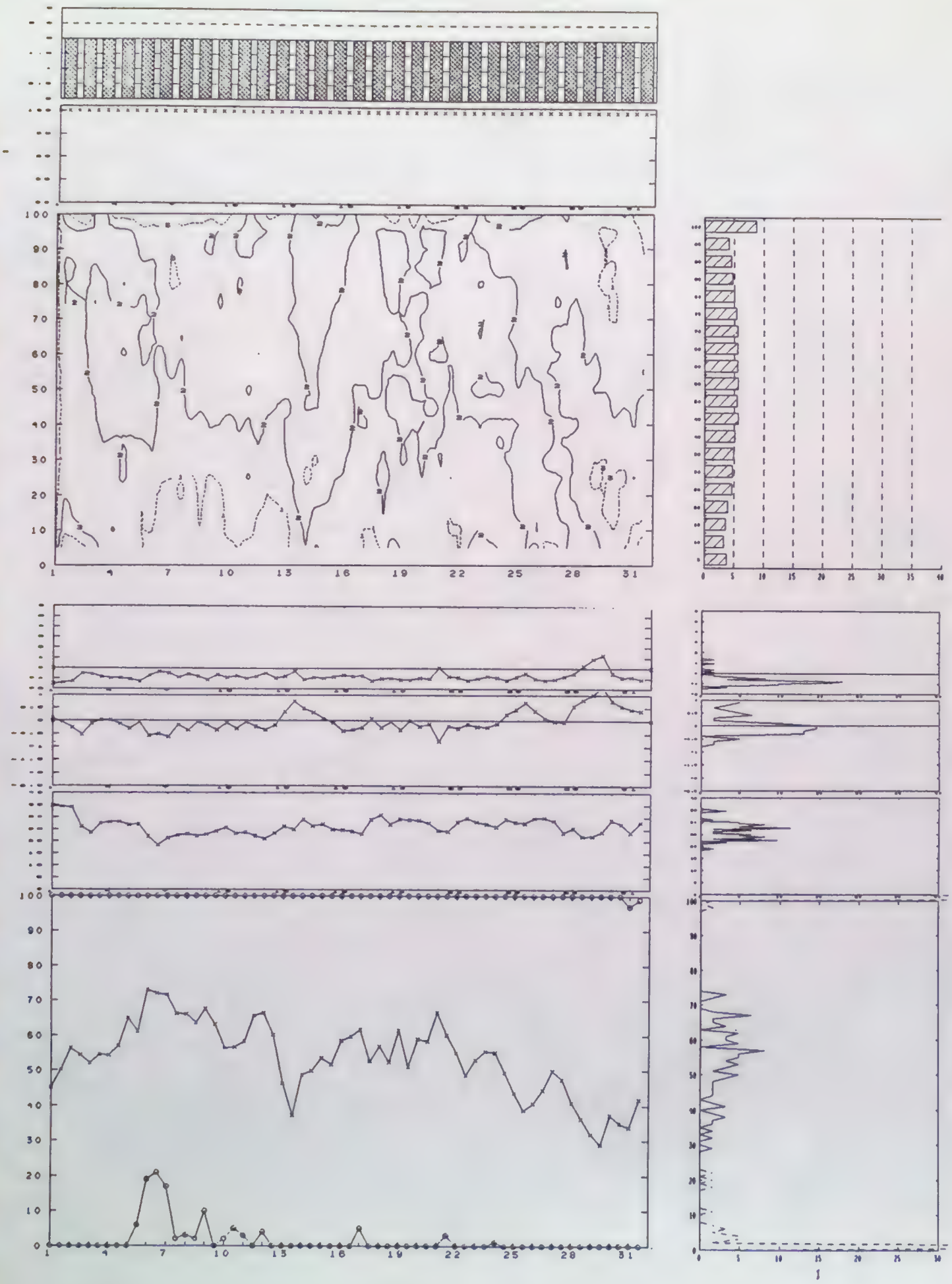

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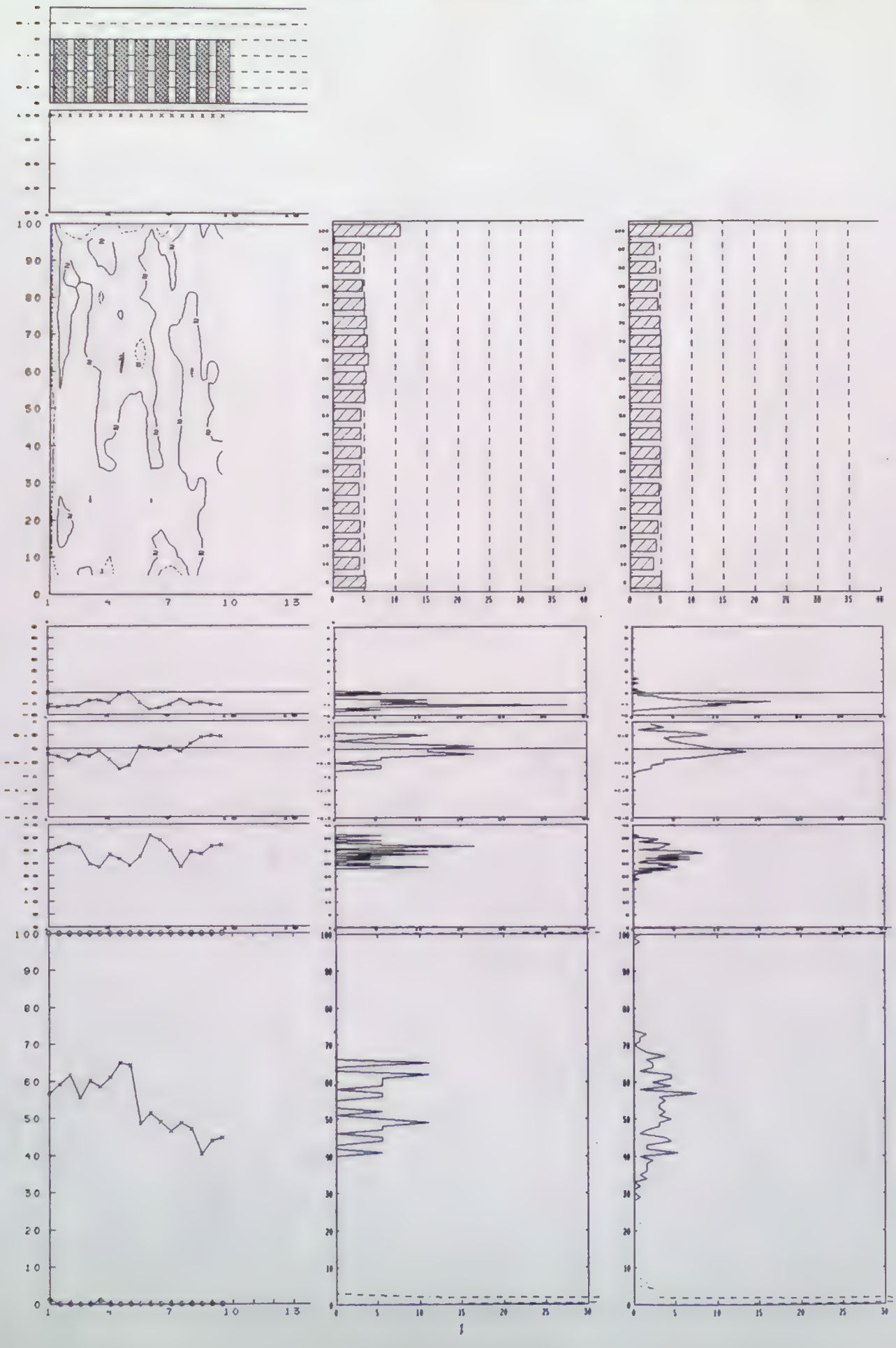

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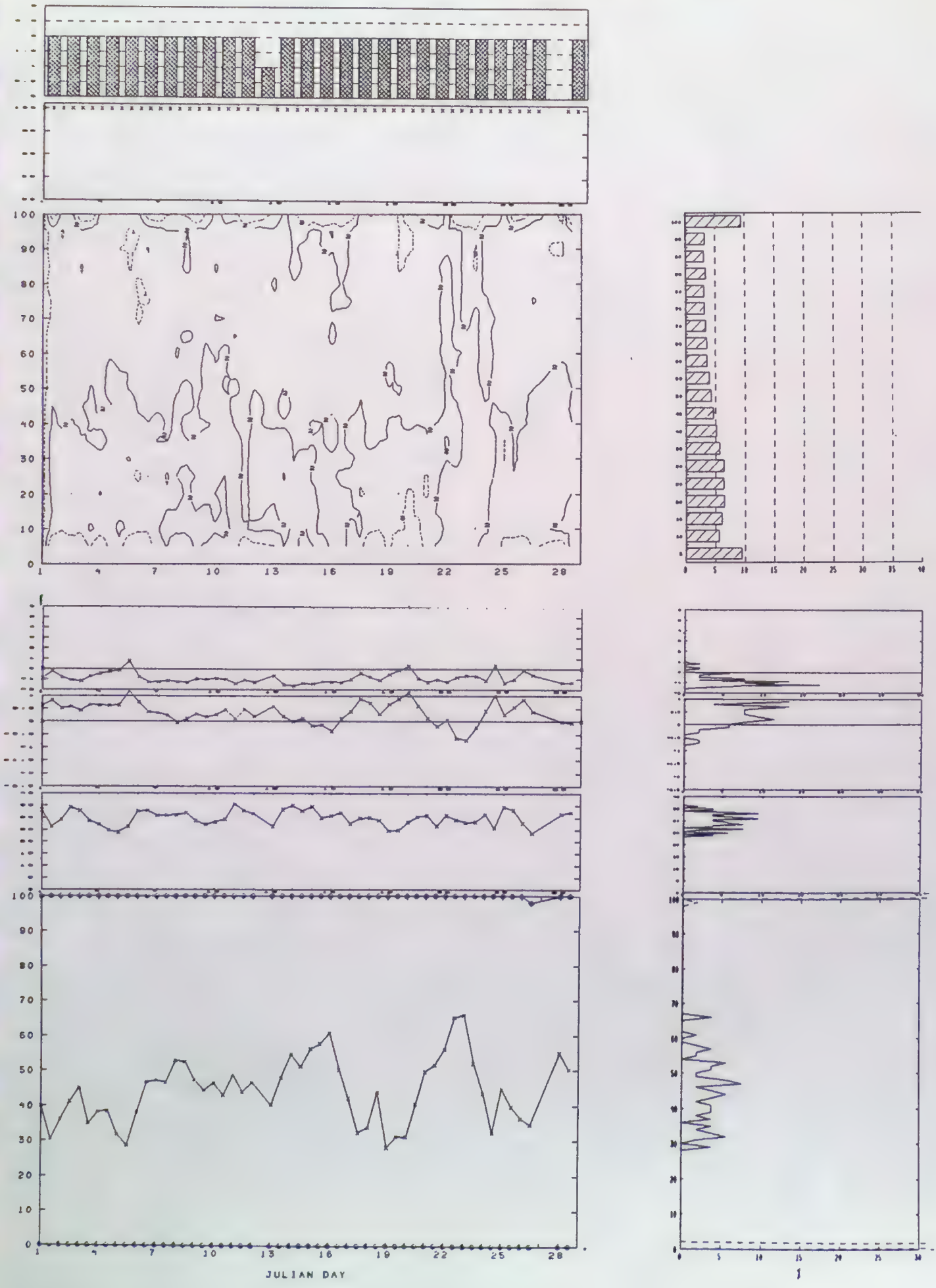

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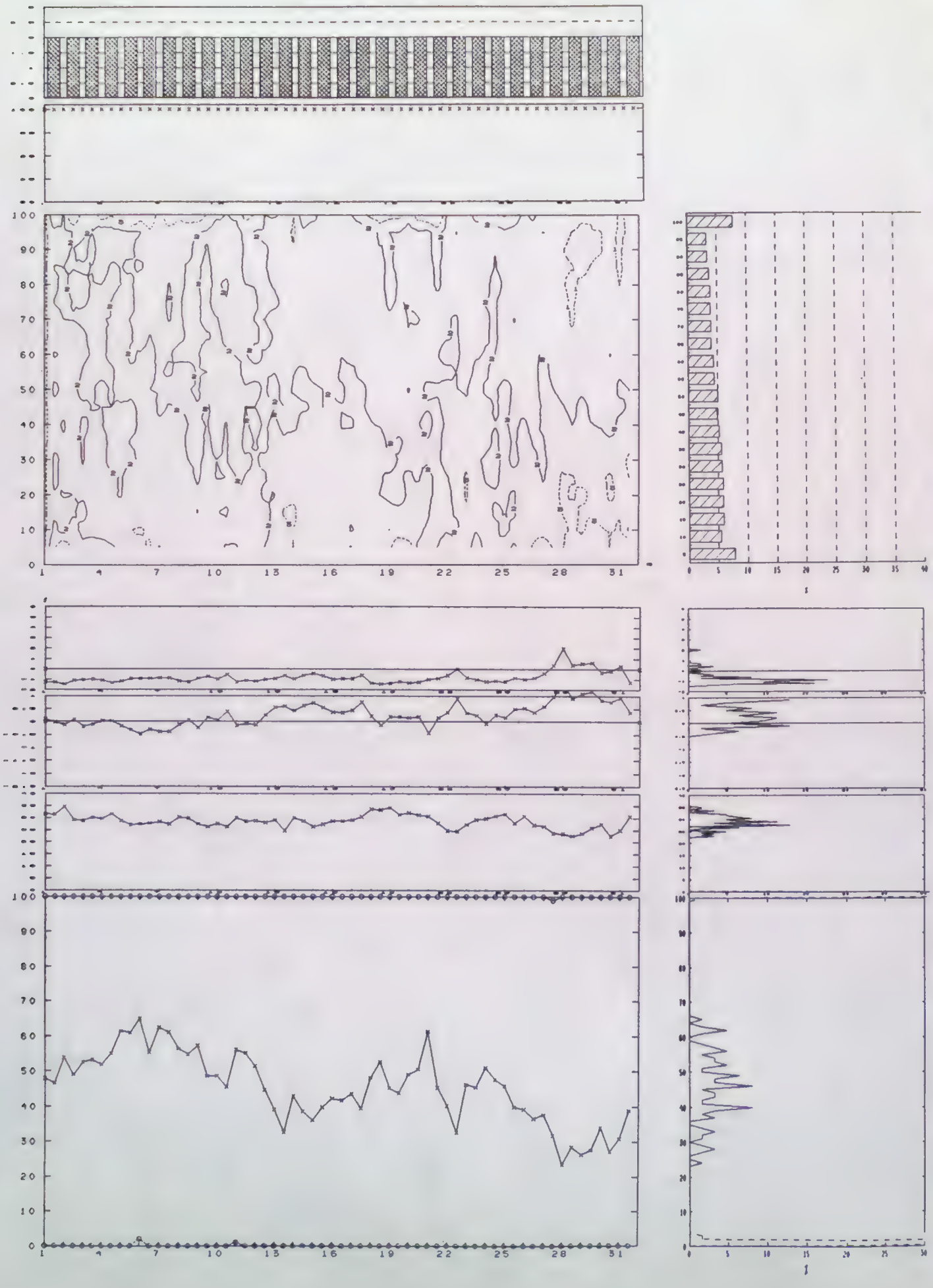

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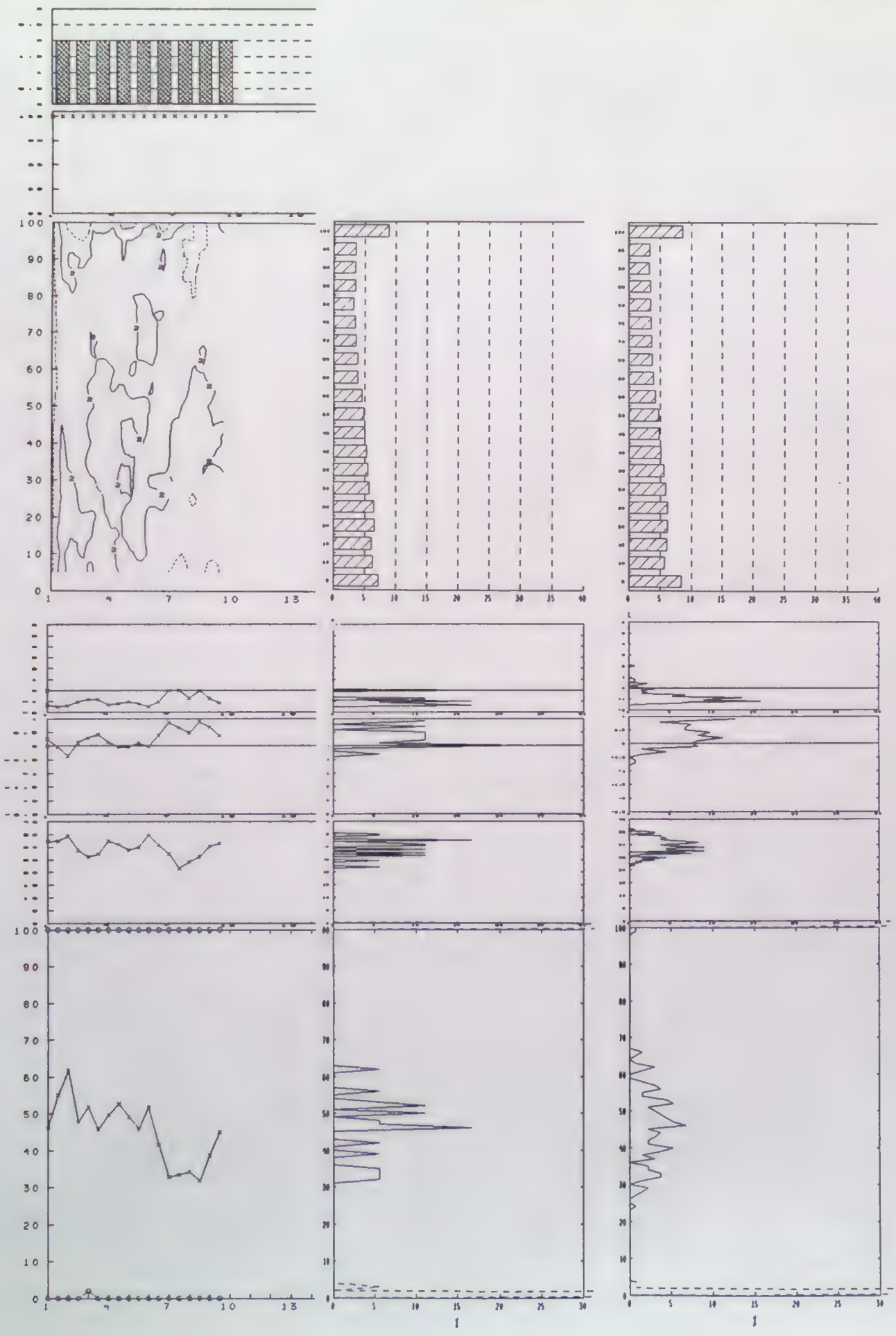

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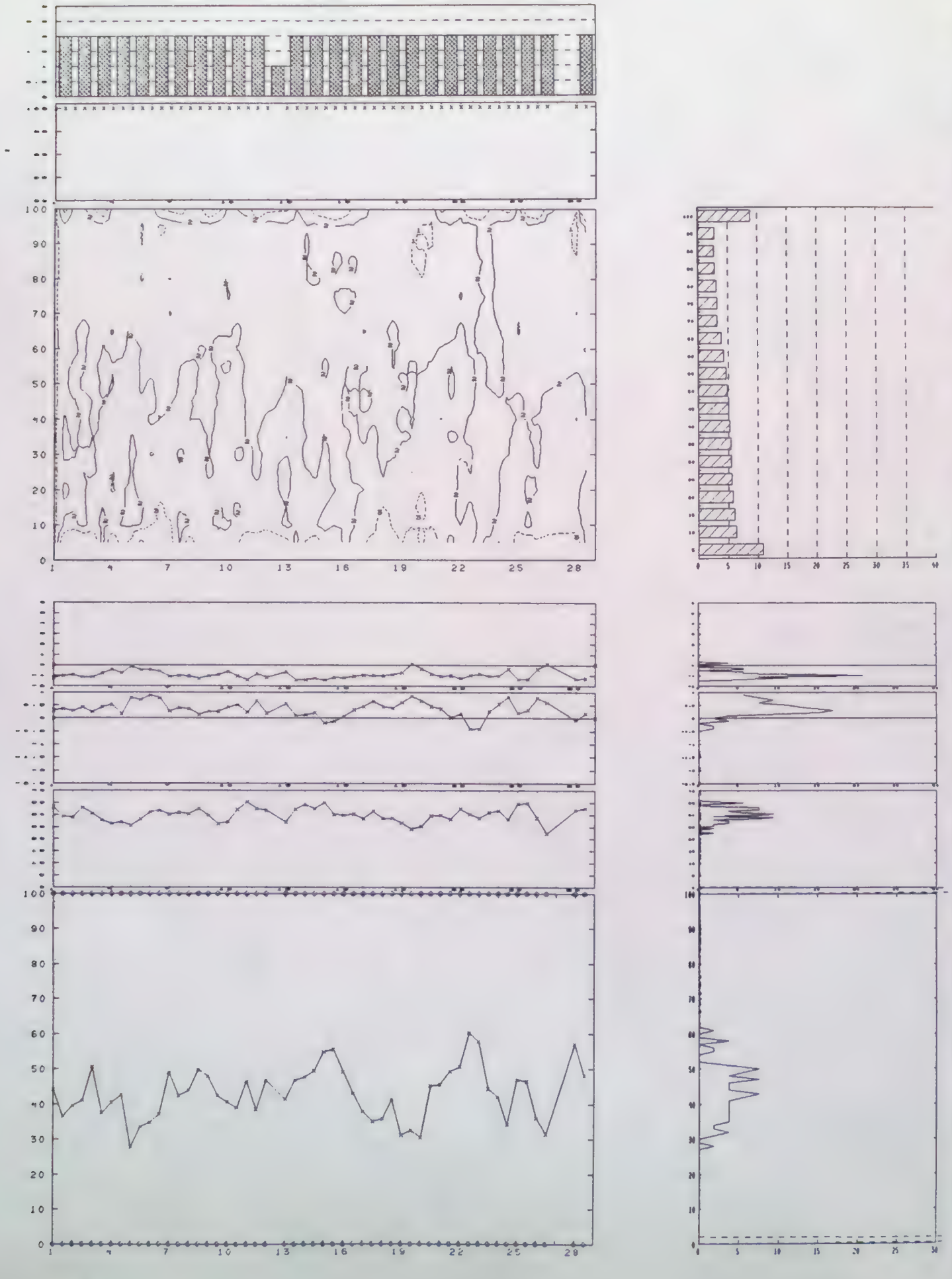

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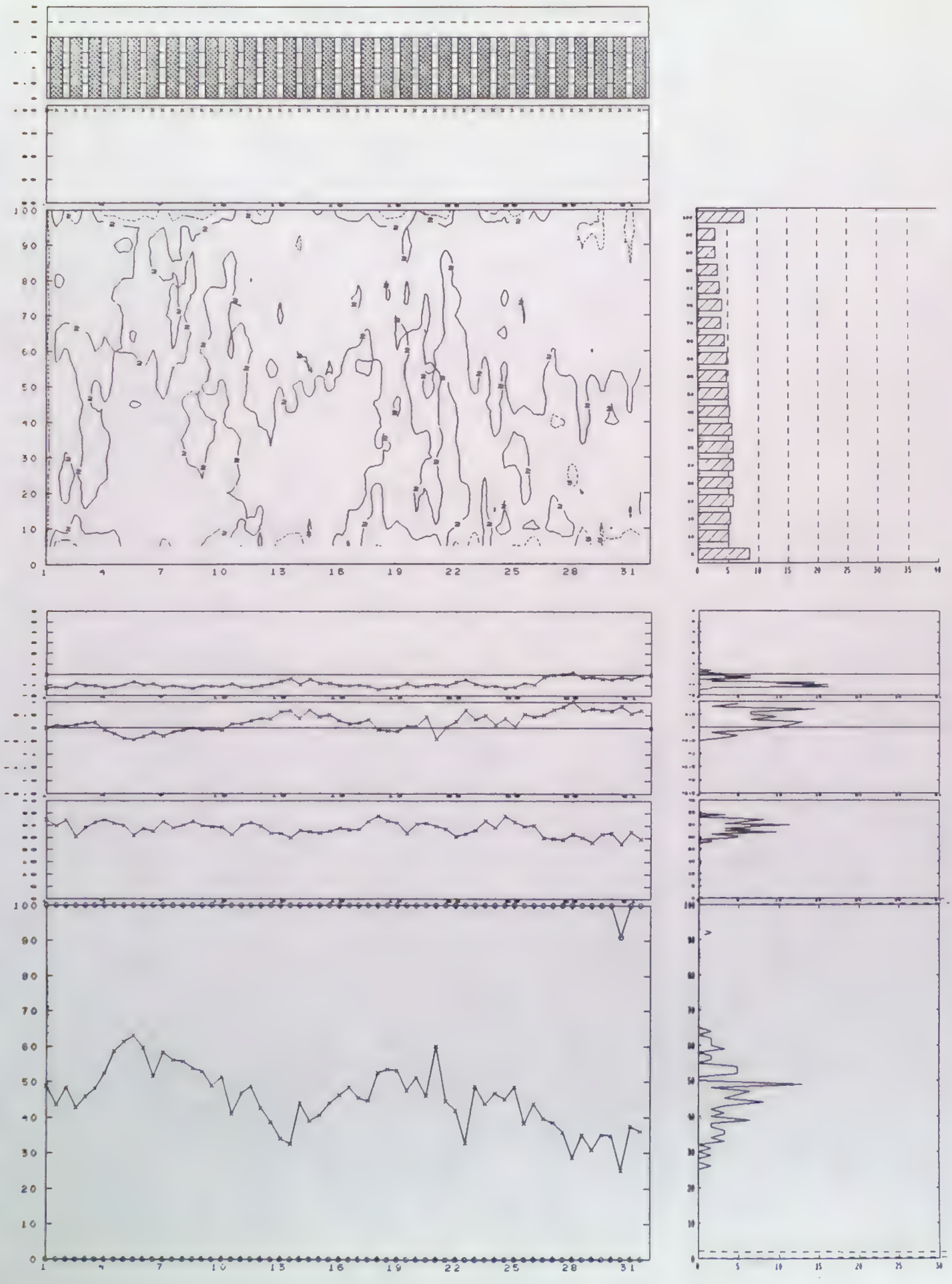

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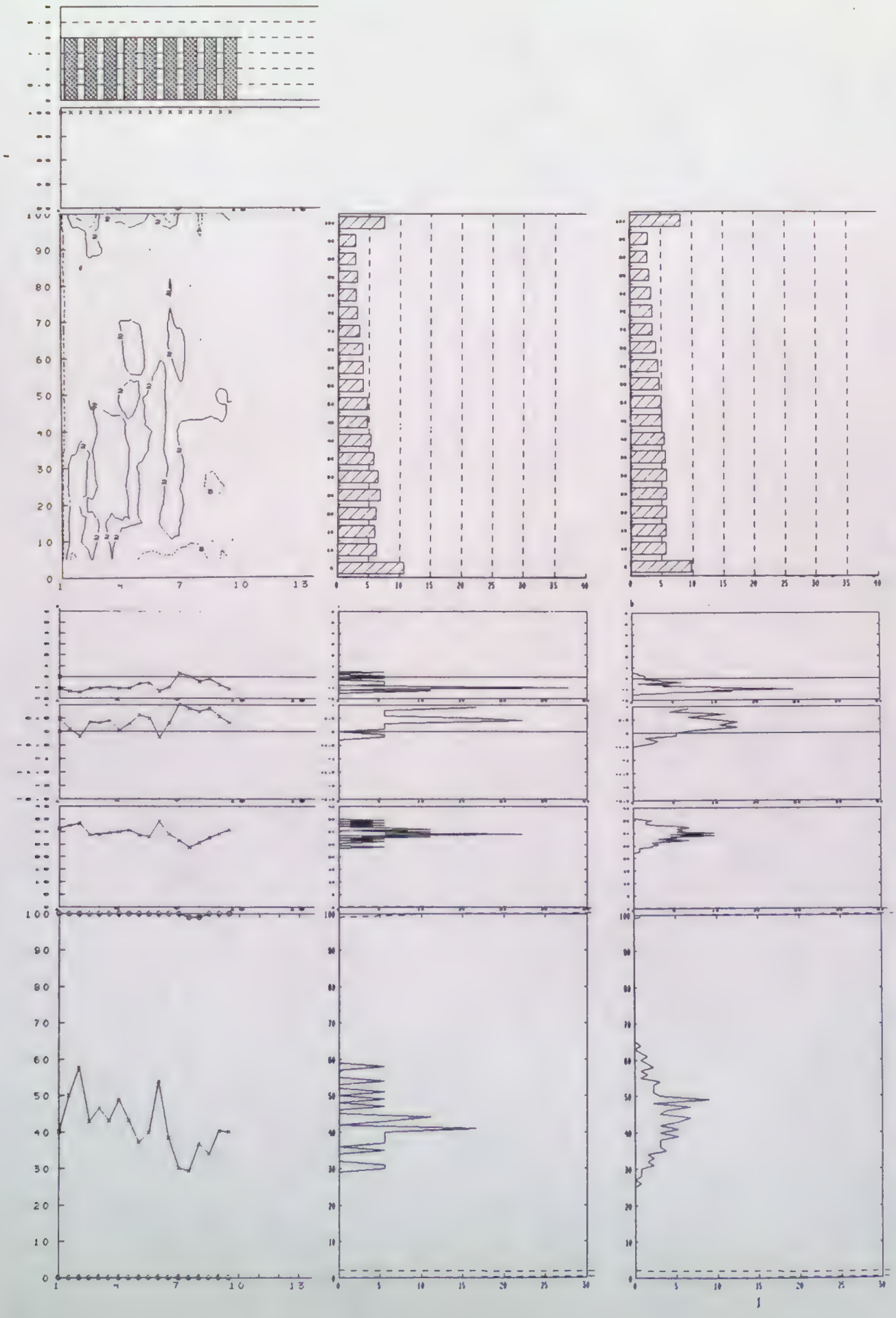

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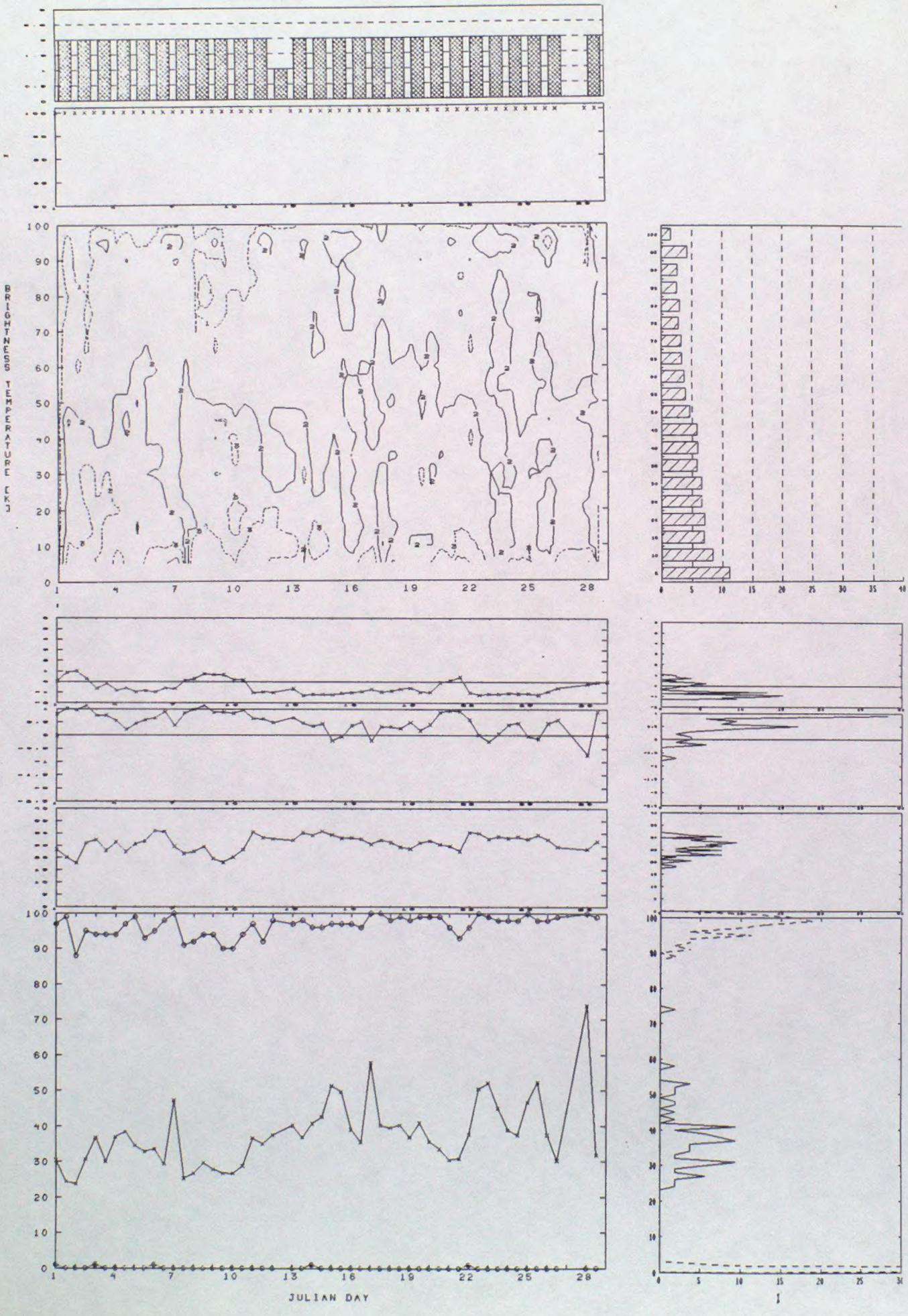

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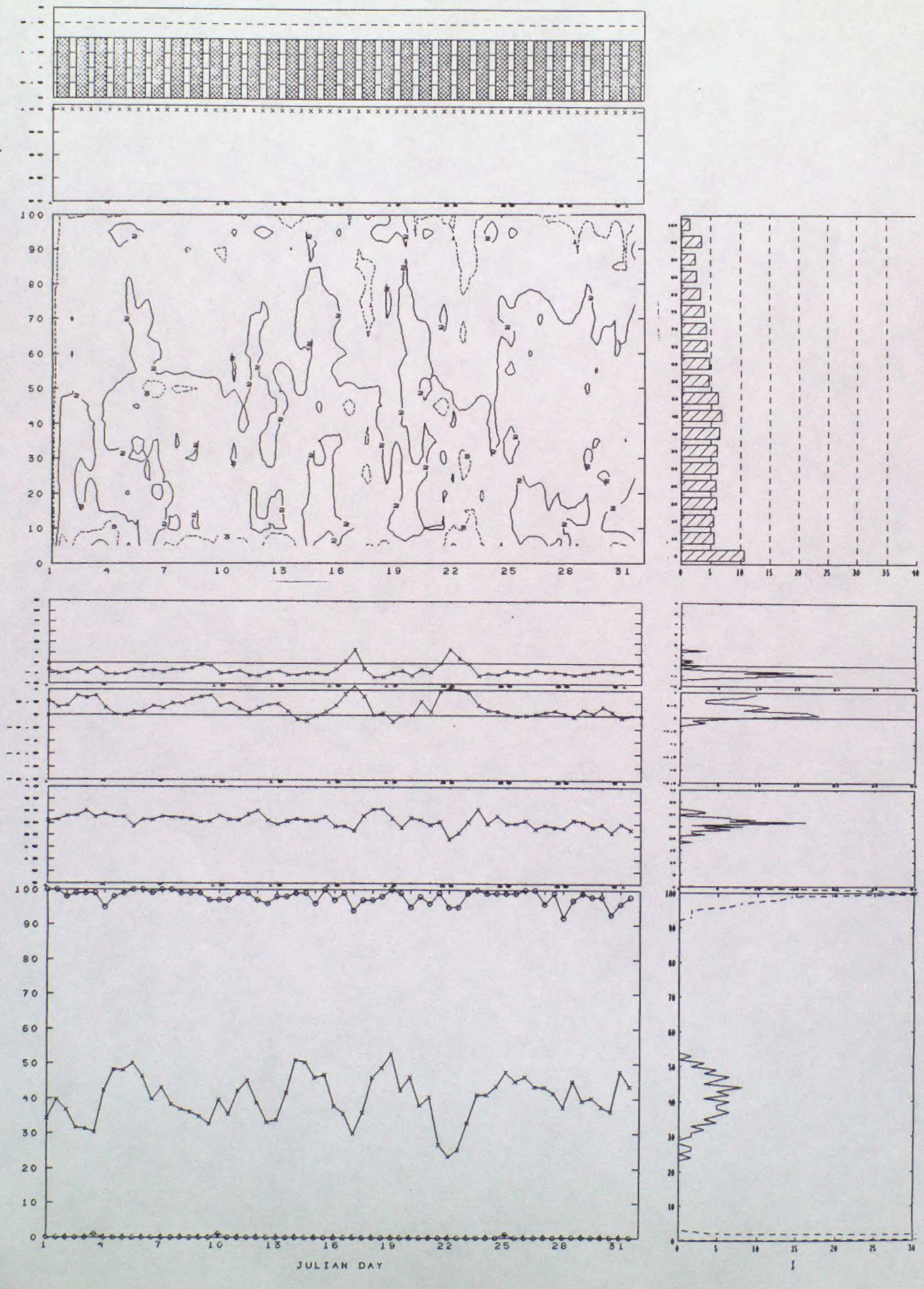

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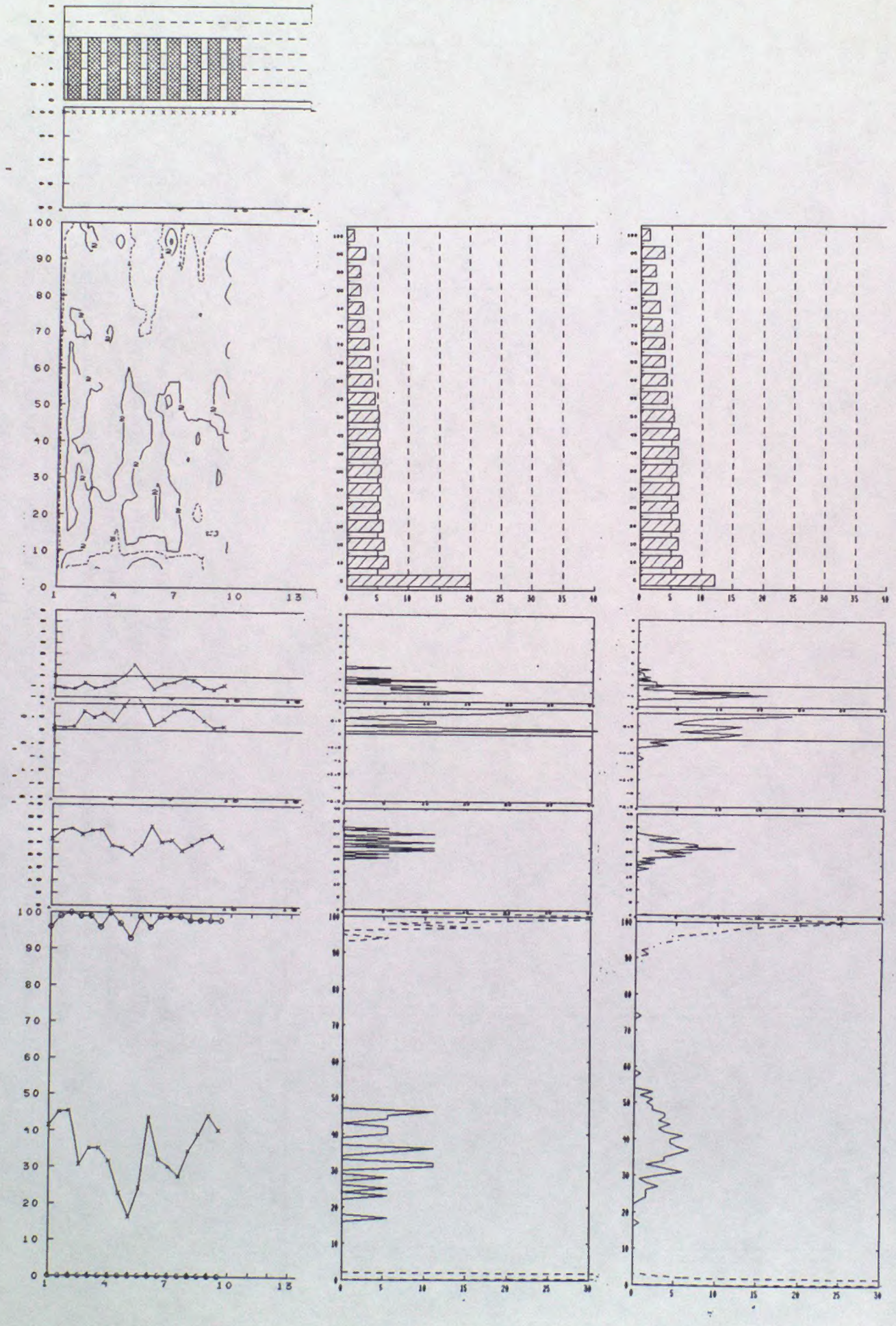

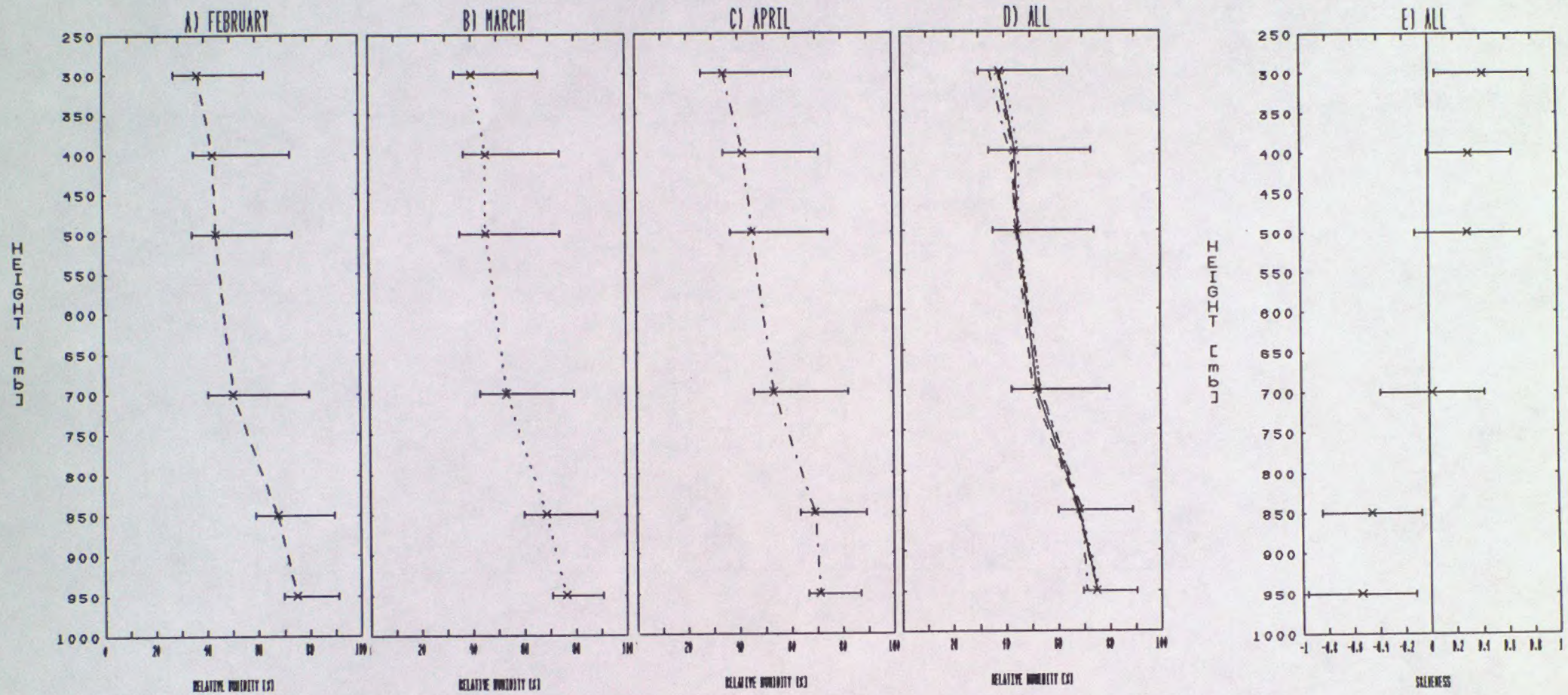

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